

## SECTION TABLE OF CONTENTS

## DIVISION 15 - MECHANICAL

## SECTION 15895

## AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

02/03

## PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 COORDINATION OF TRADES
- 1.3 DELIVERY AND STORAGE
- 1.4 FIELD MEASUREMENTS
- 1.5 SUBMITTALS

## PART 2 PRODUCTS

- 2.1 STANDARD PRODUCTS
- 2.2 ASBESTOS PROHIBITION
- 2.3 NAMEPLATES
- 2.4 EQUIPMENT GUARDS AND ACCESS
- 2.5 PIPING COMPONENTS
  - 2.5.1 Steel Pipe
  - 2.5.2 Joints and Fittings For Steel Pipe
    - 2.5.2.1 Welded Joints and Fittings
    - 2.5.2.2 Flanged Joints and Fittings
    - 2.5.2.3 Threaded Joints and Fittings
    - 2.5.2.4 Dielectric Waterways
    - 2.5.2.5 Grooved Mechanical Joints and Fittings
  - 2.5.3 Copper Tube
  - 2.5.4 Joints and Fittings For Copper Tube
  - 2.5.5 Valves
    - 2.5.5.1 Gate Valves
    - 2.5.5.2 Globe Valves
    - 2.5.5.3 Check Valves
    - 2.5.5.4 Angle Valves
    - 2.5.5.5 Ball Valves
    - 2.5.5.6 Butterfly Valves
    - 2.5.5.7 Balancing Valves
    - 2.5.5.8 Air Vents
  - 2.5.6 Strainers
  - 2.5.7 Glycol
  - 2.5.8 Backflow Preventers
  - 2.5.9 Flexible Pipe Connectors
  - 2.5.10 Pressure Gauges
  - 2.5.11 Thermometers
  - 2.5.12 Escutcheons
  - 2.5.13 Pipe Hangers, Inserts, and Supports
  - 2.5.14 Expansion Joints
    - 2.5.14.1 Slip Joints
    - 2.5.14.2 Flexible Ball Joints
    - 2.5.14.3 Bellows Type Joints
  - 2.5.15 Insulation

- 2.5.16 Condensate Drain Lines
- 2.6 ELECTRICAL WORK
- 2.7 Omitted
- 2.8 DUCTWORK COMPONENTS
  - 2.8.1 Metal Ductwork
  - 2.8.2 Fibrous Glass Ductwork
  - 2.8.3 Ductwork Accessories
    - 2.8.3.1 Duct Access Doors
    - 2.8.3.2 Fire Dampers
    - 2.8.3.3 Splitters and Manual Balancing Dampers
    - 2.8.3.4 Air Deflectors and Branch Connections
  - 2.8.4 Duct Sleeves, Framed Prepared Openings, Closure Collars
    - 2.8.4.1 Duct Sleeves
    - 2.8.4.2 Framed Prepared Openings
    - 2.8.4.3 Closure Collars
  - 2.8.5 Plenums and Casings for Field-Fabricated Units
    - 2.8.5.1 Plenum and Casings
    - 2.8.5.2 Casing
    - 2.8.5.3 Access Doors
    - 2.8.5.4 Factory-Fabricated Insulated Sheet Metal Panels
    - 2.8.5.5 Duct Liner
  - 2.8.6 Sound Attenuation Equipment
  - 2.8.7 Diffusers, Registers, and Grilles
    - 2.8.7.1 Diffusers
    - 2.8.7.2 Registers and Grilles
  - 2.8.8 Louvers
  - 2.8.9 Air Vents, Penthouses, and Goosenecks
  - 2.8.10 Bird Screens and Frames
  - 2.8.11 Radon Exhaust Ductwork
- 2.9 AIR SYSTEMS EQUIPMENT
  - 2.9.1 Fans
    - 2.9.1.1 Centrifugal Fans
    - 2.9.1.2 In-Line Centrifugal Fans
    - 2.9.1.3 Axial Flow Fans
    - 2.9.1.4 Panel Type Power Wall Ventilators
    - 2.9.1.5 Centrifugal Type Power Wall Ventilators
    - 2.9.1.6 Centrifugal Type Power Roof Ventilators
    - 2.9.1.7 Ceiling Exhaust Fans
  - 2.9.2 Coils
  - 2.9.3 Air Filters
    - 2.9.3.1 Holding Frames
    - 2.9.3.2 Filter Gauges
- 2.10 AIR HANDLING UNITS
  - 2.10.1 Field-Fabricated Air Handling Units
  - 2.10.2 Factory-Fabricated Air Handling Units
    - 2.10.2.1 Casings
    - 2.10.2.2 Heating and Cooling Coils
    - 2.10.2.3 Cooling Coils, Spray Type
    - 2.10.2.4 Air Filters
    - 2.10.2.5 Fans
    - 2.10.2.6 Access Sections and Filter/Mixing Boxes
    - 2.10.2.7 Diffuser Sections
    - 2.10.2.8 Dampers
- 2.11 TERMINAL UNITS
  - 2.11.1 Variable Air Volume (VAV) and Dual Duct Terminal Units
    - 2.11.1.1 Constant Volume, Single Duct
    - 2.11.1.2 Variable Volume, Single Duct
    - 2.11.1.3 Variable Volume, Single Duct, Fan-Powered
    - 2.11.1.4 Reheat Units

## 2.12 ENERGY RECOVERY DEVICES

## 2.12.1 Rotary Wheel

## 2.13 FACTORY PAINTING

## PART 3 EXECUTION

## 3.1 INSTALLATION

## 3.1.1 Piping

## 3.1.1.1 Joints

## 3.1.1.2 Grooved Mechanical Joints

## 3.1.1.3 Flanges and Unions

## 3.1.2 Supports

## 3.1.2.1 General

## 3.1.2.2 Seismic Requirements (Pipe Supports and Structural Bracing)

## 3.1.2.3 Pipe Hangers, Inserts and Supports

## 3.1.3 Anchors

## 3.1.4 Pipe Sleeves

## 3.1.4.1 Roof and Floor Sleeves

## 3.1.4.2 Fire Seal

## 3.1.4.3 Escutcheons

## 3.1.5 Condensate Drain Lines

## 3.1.6 Pipe-Alignment Guides

## 3.1.7 Air Vents and Drains

## 3.1.7.1 Vents

## 3.1.7.2 Drains

## 3.1.8 Valves

## 3.1.9 Equipment and Installation

## 3.1.10 Access Panels

## 3.1.11 Flexible Connectors

## 3.1.12 Sleeved and Framed Openings

## 3.1.13 Metal Ductwork

## 3.1.13.1 Underground Ductwork

## 3.1.13.2 Radon Exhaust Ductwork

## 3.1.13.3 Light Duty Corrosive Exhaust Ductwork

## 3.1.14 Fibrous Glass Ductwork

## 3.1.15 FRP Ductwork

## 3.1.16 Acoustical Duct Lining

## 3.1.17 Dust Control

## 3.1.18 Insulation

## 3.1.19 Duct Test Holes

## 3.1.20 Power Roof Ventilator Mounting

## 3.1.21 Power Transmission Components Adjustment

## 3.2 FIELD PAINTING AND IDENTIFICATION SYSTEMS

## 3.2.1 Identification Tags

## 3.2.2 Finish Painting and Pipe Color Code Marking

## 3.2.3 Color Coding Scheme for Locating Hidden Utility Components

## 3.3 PIPING HYDROSTATIC TEST

## 3.4 DUCTWORK LEAK TEST

## 3.5 DAMPER ACCEPTANCE TEST

## 3.6 TESTING, ADJUSTING, AND BALANCING

## 3.7 PERFORMANCE TESTS

## 3.8 CLEANING AND ADJUSTING

## 3.9 FIELD TRAINING

-- End of Section Table of Contents --

## SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM  
02/03

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

## AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 260	(2001) Sound Rating of Ducted Air Moving and Conditioning Equipment
ARI 410	(1991) Forced-Circulation Air-Cooling and Air-Heating Coils
ARI 430	(1999) Central-Station Air-Handling Units
ARI 880	(1998) Air Terminals
ARI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

## AIR CONDITIONING CONTRACTORS OF AMERICA (ACCA)

ACCA Manual 4	(2001) Installation Techniques for Perimeter Heating & Cooling; 11th Edition
---------------	--

## AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210	(1999) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans

## AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings

## ASTM INTERNATIONAL (ASTM)

ASTM A 47/A 47M	(1999) Ferritic Malleable Iron Castings
ASTM A 53/A 53M	(2001) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 106	(1999e1) Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A 123/A 123M	(2001a) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 181/A 181M	(2001) Carbon Steel Forgings, for General-Purpose Piping
ASTM A 183	(1998) Carbon Steel Track Bolts and Nuts
ASTM A 193/A 193M	(2001b) Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 234/A 234M	(2001a) Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
ASTM A 536	(1984; R 1999e1) Ductile Iron Castings
ASTM A 733	(2001) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM A 924/A 924M	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 75	(1999) Seamless Copper Tube
ASTM B 88	(1999e1) Seamless Copper Water Tube
ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM B 650	(1995) Electrodeposited Engineering Chromium Coatings on Ferrous Substrates
ASTM B 813	(2000) Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
ASTM C 916	(1985; R 1996e1) Adhesives for Duct Thermal Insulation
ASTM C 1071	(2000) Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
ASTM D 520	(2000) Zinc Dust Pigment
ASTM D 1384	(2001) Corrosion Test for Engine Coolants in Glassware

ASTM D 1654	(1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 1785	(1999) Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2000	(2001) Rubber Products in Automotive Applications
ASTM D 2466	(2001) Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2564	(1996a) Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
ASTM D 2855	(1996) Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM E 84	(2001) Surface Burning Characteristics of Building Materials
ASTM E 437	(1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series)
ASTM F 1199	(1988; R 1998) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)
ASTM F 1200	(1988; R 1998) Fabricated (Welded) Pipe Line Strainers (Above 150 psig and 150 degrees F)

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 68	(1997) Laboratory Method of Testing to Determine the Sound Power in a Duct
ASHRAE 70	(1991) Method of Testing for Rating the Performance of Air Outlets and Inlets
ASHRAE 84	(1991) Method of Testing Air-to-Air Heat Exchangers

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2001) Pipe Threads, General Purpose, Inch
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.5	(1996) Pipe Flanges and Flanged Fittings
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings

ASME B16.11	(2001) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2001) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.22	(1995) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions
ASME B31.1	(2001) Power Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element

## AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(1997) Grooved and Shouldered Joints
-----------	--------------------------------------

## AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2000) Structural Welding Code - Steel
----------------	--

## EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(1998; 7th Edition; Addenda 2000) EJMA Standards
-----------	--

## MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25	(1998) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1998) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1997) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-72	(1999) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(1997) Bronze Gate, Globe, Angle and Check Valves

MSS SP-85 (1994) Cast Iron Globe & Angle Valves,  
Flanged and Threaded Ends

MSS SP-110 (1996) Ball Valves Threaded,  
Socket-Welding, Solder Joint, Grooved and  
Flared Ends

## NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (1998) Motors and Generators

## NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A (1999) Installation of Air Conditioning  
and Ventilating Systems

## NORTH AMERICAN INSULATION MANUFACTURERS ASSOCIATION (NAIMA)

NAIMA AH115 (2001) Fibrous Glass Duct Construction  
Standards

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION  
(SMACNA)

SMACNA HVAC Duct Const Stds (1995; Addenda Nov 1997; 6th Printing  
2001) HVAC Duct Construction Standards -  
Metal and Flexible

SMACNA Industry Practice (1975; 8th Printing 1997) Accepted  
Industry Practice for Industrial Duct  
Construction

SMACNA Install Fire Damp HVAC (1992; 2th Printing 1996) Fire, Smoke and  
Radiation Damper Installation Guide for  
HVAC Systems

SMACNA Leakage Test Mnl (1985; 6th Printing 1997) HVAC Air Duct  
Leakage Test Manual

## UNDERWRITERS LABORATORIES (UL)

UL 181 (1996; Rev thru Dec 1998) Factory-Made Air  
Ducts and Air Connectors

UL 555 (1999; Rev thru Jan 2002) Fire Dampers

UL 586 (1996; Rev thru Apr 2000) High-Efficiency,  
Particulate, Air Filter Units

UL 723 (1996; Rev thru Sep 2001) Test for Surface  
Burning Characteristics of Building  
Materials

UL 900 (1994; Rev thru Oct 1999) Air Filter Units

UL Elec Const Dir (2001) Electrical Construction Equipment  
Directory



UL Fire Resist Dir

(2001) Fire Resistance Directory (2 Vol.)

## 1.2 COORDINATION OF TRADES

Ductwork, piping offsets, fittings, and accessories shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

## 1.3 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, all pipes shall either be capped or plugged until installed.

## 1.4 FIELD MEASUREMENTS

After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

## 1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

### SD-02 Shop Drawings

Drawings; G, RE  
Installation; G, RE

Drawings showing equipment layout, including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of all guides and anchors, the load imposed on each support or anchor, and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

### SD-03 Product Data

Components and Equipment; G, RE

Manufacturer's catalog data included with the detail drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

#### a. Piping Components

- b. Ductwork Components
- c. Air Systems Equipment
- d. Air Handling Units
- e. Energy Recovery Devices
- f. Terminal Units

#### Test Procedures

Proposed test procedures for piping hydrostatic test, ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

#### Welding Procedures

A copy of qualified welding procedures, at least 2 weeks prior to the start of welding operations.

#### Diagrams

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

#### Manufacturer's Experience

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

#### Welded Joints

A list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations.

#### Performance Tests

Proposed test schedules for hydrostatic test of piping, ductwork leak test, and performance tests, at least 2 weeks prior to the start of related testing.

#### Field Training

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

#### SD-06 Test Reports

#### Performance Tests

Testing, Adjusting, and Balancing; G, RE

Test reports for the piping hydrostatic test, ductwork leak test, and performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

#### SD-07 Certificates

##### Bolts

Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, and the number of each type of bolt to be furnished.

#### SD-10 Operation and Maintenance Data

##### Operating and Maintenance Instructions

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization submitted shall be capable of providing 4 hour onsite response to a service call on an emergency basis.

## PART 2 PRODUCTS

### 2.1 STANDARD PRODUCTS

Components and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year manufacturer's experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization.

### 2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

### 2.3 NAMEPLATES

Equipment shall have a nameplate installed by the manufacturer that

identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

## 2.4 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified.

## 2.5 PIPING COMPONENTS

### 2.5.1 Steel Pipe

Steel pipe shall conform to ASTM A 53/A 53M, Schedule 40, Grade A or B, Type E or S.

### 2.5.2 Joints and Fittings For Steel Pipe

Joints shall be welded, flanged, threaded, or grooved as indicated. If not otherwise indicated, piping 1 inch and smaller shall be threaded; piping larger than 1 inch and smaller than 3 inches shall be either threaded, grooved, or welded; and piping 3 inches and larger shall be grooved, welded, or flanged. Rigid grooved mechanical joints and fittings may only be used in serviceable aboveground locations where the temperature of the circulating medium does not exceed 230 degrees F. Flexible grooved joints shall be used only as a flexible connector with grooved pipe system. Unless otherwise specified, grooved piping components shall meet the corresponding criteria specified for the similar welded, flanged, or threaded component specified herein. The manufacturer of each fitting shall be permanently identified on the body of the fitting according to MSS SP-25.

#### 2.5.2.1 Welded Joints and Fittings

Welded fittings shall conform to ASTM A 234/A 234M, and shall be identified with the appropriate grade and marking symbol. Butt-welded fittings shall conform to ASME B16.9. Socket-welded fittings shall conform to ASME B16.11.

#### 2.5.2.2 Flanged Joints and Fittings

Flanges shall conform to ASTM A 181/A 181M and ASME B16.5, Class 150. Gaskets shall be nonasbestos compressed material according to ASME B16.21, 1/16 inch thickness, full face or self-centering flat ring type. The gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Bolts, nuts, and bolt patterns shall conform to ASME B16.5. Bolts shall be high or intermediate strength material conforming to ASTM A 193/A 193M.

#### 2.5.2.3 Threaded Joints and Fittings

Threads shall conform to ASME B1.20.1. Unions shall conform to ASME B16.39, Class 150. Nipples shall conform to ASTM A 733. Malleable iron fittings shall conform to ASME B16.3, type as required to match piping.

#### 2.5.2.4 Dielectric Waterways

Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

#### 2.5.2.5 Grooved Mechanical Joints and Fittings

Joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Fitting and coupling houses shall be malleable iron conforming to ASTM A 47/A 47M, Grade 32510; ductile iron conforming to ASTM A 536, Grade 65-45-12; or steel conforming to ASTM A 106, Grade B or ASTM A 53/A 53M. Gaskets shall be molded synthetic rubber with central cavity, pressure responsive configuration and shall conform to ASTM D 2000 Grade No. 2CA615A15B44F17Z for circulating medium up to 230 degrees F or Grade No. M3BA610A15B44Z for circulating medium up to 200 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts shall be steel and shall conform to ASTM A 183.

#### 2.5.3 Copper Tube

Copper tube shall conform to ASTM B 88, and ASTM B 88M, Type K or L.

#### 2.5.4 Joints and Fittings For Copper Tube

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Grooved mechanical joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A 536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D 2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A 183.

#### 2.5.5 Valves

Valves shall be Class 125 and shall be suitable for the intended application. Valves shall meet the material, fabrication and operating requirements of ASME B31.1. Chain operators shall be provided for valves located 10 feet or higher above the floor. Valves in sizes larger than 1 inch and used on steel pipe systems, may be provided with rigid grooved mechanical joint ends. Such grooved end valves shall be subject to the same requirements as rigid grooved mechanical joints and fittings and, shall be provided by the same manufacturer as the grooved pipe joint and fitting system.

##### 2.5.5.1 Gate Valves

Gate valves 2-1/2 inches and smaller shall conform to MSS SP-80 and shall

be bronze with rising stem and threaded, solder, or flanged ends. Gate valves 3 inches and larger shall conform to MSS SP-70 and shall be cast iron with bronze trim, outside screw and yoke, and flanged or threaded ends.

#### 2.5.5.2 Globe Valves

Globe valves 2-1/2 inches and smaller shall conform to MSS SP-80, bronze, threaded, soldered, or flanged ends. Globe valves 3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged, or threaded ends.

#### 2.5.5.3 Check Valves

Check valves 2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Check valves 3 inches and larger shall conform to MSS SP-71 and shall be cast iron with bronze trim and flanged or threaded ends.

#### 2.5.5.4 Angle Valves

Angle valves 2-1/2 inches and smaller shall conform to MSS SP-80 and shall be bronze with threaded, soldered, or flanged ends. Angle valves 3 inches and larger shall conform to MSS SP-85 and shall be cast iron with bronze trim and flanged, or threaded ends.

#### 2.5.5.5 Ball Valves

Ball valves 1/2 inch and larger shall conform to MSS SP-72 or MSS SP-110, and shall be ductile iron or bronze with threaded, soldered, or flanged ends.

#### 2.5.5.6 Butterfly Valves

Butterfly valves shall be 2 flange or lug wafer type, and shall be bubble-tight at 150 psig. Valve bodies shall be cast iron, malleable iron, or steel ASTM A 167, Type 404 or Type 316, corrosion resisting steel stems, bronze or corrosion resisting steel discs, and synthetic rubber seats shall be provided. Valves smaller than 8 inches shall have throttling handles with a minimum of seven locking positions. Valves 8 inches and larger shall have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Valves in insulated lines shall have extended neck to accommodate insulation thickness.

#### 2.5.5.7 Balancing Valves

Balancing valves 2 inches or smaller shall be bronze with NPT connections for black steel pipe and brazed connections for copper tubing. Valves 1 inch or larger may be all iron with threaded or flanged ends. The valves shall have a square head or similar device and an indicator arc and shall be designed for 250 degrees F. Iron valves shall be lubricated, nonlubricated, or tetrafluoroethylene resin-coated plug valves. In lieu of plug valves, ball valves may be used. Plug valves and ball valves 8 inches or larger shall be provided with manual gear operators with position indicators. In lieu of balancing valves specified, automatic flow control valves may be provided to maintain constant flow, and shall be designed to be sensitive to pressure differential across the valve to provide the required opening. Valves shall be selected for the flow required and provided with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Valves

shall control the flow within 5 percent of the tag rating. Valves shall be suitable for the maximum operating pressure of 125 psig or 150 percent of the system operating pressure, whichever is the greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, the system pump head capability shall be appropriately increased. Where flow readings are provided by remote or portable meters, valve bodies shall be provided with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. The pipe extensions shall be provided with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. A portable meter furnished with accessory kit as recommended by the automatic valve manufacturer shall be provided. Automatic flow control valve specified may be substituted for venturi tubes or orifice plate flow measuring devices.

#### 2.5.5.8 Air Vents

Manual air vents shall be brass or bronze valves or cocks suitable for pressure rating of piping system and furnished with threaded plugs or caps. Automatic air vents shall be float type, cast iron, stainless steel, or forged steel construction, suitable for pressure rating of piping system.

#### 2.5.6 Strainers

Strainer shall be in accordance with ASTM F 1199 or ASTM F 1200, except as modified herein. Strainer shall be the cleanable, basket or "Y" type, the same size as the pipeline. The strainer bodies shall be fabricated of cast iron with bottoms drilled, and tapped. The bodies shall have arrows clearly cast on the sides indicating the direction of flow. Each strainer shall be equipped with removable cover and sediment screen. The screen shall be made of minimum 22 gauge brass sheet, monel, corrosion-resistant steel, with small perforations numbering not less than 400 per square inch to provide a net free area through the basket of at least 3.3 times that of the entering pipe. The flow shall be into the screen and out through the perforations.

#### 2.5.7 Glycol

The glycol shall be tested according to ASTM D 1384 and shall cause less than 0.5 mils penetration per year for all system metals. The glycol shall contain corrosion inhibitors. Silicon based inhibitors shall not be used. The solution shall be compatible with all wetted items within the system.

#### 2.5.8 Backflow Preventers

Backflow preventers shall be according to Section 15400A PLUMBING, GENERAL PURPOSE.

#### 2.5.9 Flexible Pipe Connectors

Flexible pipe connectors shall be designed for 125 psi or 150 psi service as appropriate for the static head plus the system head, and 230 degrees F for grooved end flexible connectors. The flexible section shall be constructed of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. The flexible section shall be suitable for intended service with end connections to match adjacent piping. Flanged assemblies shall be equipped with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors shall be as recommended by

the manufacturer for the service intended. Internal sleeves or liners, compatible with circulating medium, shall be provided when recommended by the manufacturer. Covers to protect the bellows shall be provided where indicated.

#### 2.5.10 Pressure Gauges

Gauges shall conform to ASME B40.1 and shall be provided with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 3-1/2 inches in diameter and shall have a range from 0 psig to approximately 1.5 times the maximum system working pressure.

#### 2.5.11 Thermometers

Thermometers shall have brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a 9 inch scale, and shall have rigid stems with straight, angular, or inclined pattern.

#### 2.5.12 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or setscrews.

#### 2.5.13 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

#### 2.5.14 Expansion Joints

##### 2.5.14.1 Slip Joints

Expansion joints shall provide for either single or double slip of the connected pipes, as required or indicated, and for not less than the traverse indicated. The joints shall be designed for working temperature and pressure suitable for the application, but not less than 150 psig, and shall be according to applicable requirements of EJMA Stds and ASME B31.1.

End connections shall be flanged or beveled for welding as indicated. Joint shall be provided with an anchor base where required or indicated. Where adjoining pipe is carbon steel, the sliding slip shall be seamless steel plated with a minimum of 2 mils of hard chrome according to ASTM B 650.

All joint components shall be suitable for the intended service. Initial setting shall be made according to the manufacturer's recommendations to compensate for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall be not more than 4 inches or smaller, guides shall be installed not more than 2 feet from the joint. Service outlets shall be provided where indicated.

##### 2.5.14.2 Flexible Ball Joints

Flexible ball joints shall conform to EJMA Stds and ASME B31.1 and be constructed of alloys as appropriate for the service intended. Where so indicated, the ball joint shall be designed for packing injection under full line pressure to contain leakage. The joint ends shall be threaded to 2 inches only, grooved, flanged, or beveled for welding as indicated or required and shall be capable of absorbing a minimum of 15-degree angular flex and 360 degree rotation. Balls and sockets shall be suitable for the



intended service. The exterior spherical surface of carbon steel balls shall be plated with mils of hard chrome according to ASTM B 650. The ball type joints shall be designed and constructed according to EJMA Stds and ASME B31.1 where applicable. Where required, flanges shall conform to ASME B16.5.

#### 2.5.14.3 Bellows Type Joints

Bellows type joints shall be flexible, guided expansion joints. The expansion element shall be stabilized corrosion resistant steel. Bellows type expansion joints shall conform to the applicable requirements of EJMA Stds with internal sleeves. Guiding of piping on both sides of expansion joint shall be according to the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application but not less than 150 psig.

#### 2.5.15 Insulation

Shop and field applied insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 2.5.16 Condensate Drain Lines

Condensate drainage shall be provided for each item of equipment that generates condensate as specified for drain, waste, and vent piping systems in Section 15400A PLUMBING, GENERAL PURPOSE.

### 2.6 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 1 hp and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 10 hp or less. Adjustable frequency drives shall be used for larger motors.

#### 2.7 Omitted

### 2.8 DUCTWORK COMPONENTS

#### 2.8.1 Metal Ductwork

\*5

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds, hot dipped galvanized unless otherwise specified. Elbows shall be radius type with a centerline radius of 1.5 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure 1/2, 1, and 2 inch w.g.

ductwork shall meet the requirements of Seal Class C. 3 through 10 inch w. g. shall meet the requirements of Seal Class A. All ductwork in VAV systems upstream of the VAV boxes shall meet the requirements of Seal Class A. Sealants shall conform to fire hazard classification specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS and shall be suitable for the range of air distribution and ambient temperatures that it will be exposed to. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be applied over the outside of the joint to at least 2 inch band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Outdoor air intake ducts and plenums shall be fabricated with watertight soldered or brazed joints and seams.

#### 2.8.2 Fibrous Glass Ductwork

Fibrous glass ductwork may be provided in lieu of sheet metal ductwork except that fibrous glass ductwork will not be allowed in fan and equipment rooms, where subject to traffic or weather damage, for outside air intakes, for risers of more than two stories, in kitchen or fume exhaust ducts, to convey solids or corrosive gases, in concrete, for burial below grade, as casings or housings, or in systems used for life support systems. Fibrous glass ductwork, including all components, shall be fabricated according to NAIMA AH115 where the velocity and the static pressure are within its scope. Where the velocity or static pressure exceeds these limits, the ductwork manufacturer shall certify that the ductwork is intended for the velocities and pressures to be encountered, and that the proposed installation meets all performance criteria specified herein for metal ductwork. Fibrous glass ductwork shall have the thermal equivalent of the insulation specified for metal ductwork in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Field or factory fabricated fibrous glass ductwork shall conform to UL 181, Class 1. Duct wall penetrations, transverse joints and longitudinal seams shall be sealed as instructed by the manufacturer by one of the methods prescribed by NAIMA AH115, where applicable, except that pressure sensitive tape shall not be used as a sealant. All items necessary for a complete installation shall be provided as specified for sheet metal duct systems.

#### 2.8.3 Ductwork Accessories

##### 2.8.3.1 Duct Access Doors

Access doors shall be provided in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and heating and cooling coils. Doors shall be minimum 15 x 18 inches, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 24 x 24 inches or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

#### 2.8.3.2 Fire Dampers

Fire dampers shall be 1.5 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. The Contractor shall perform the fire damper test as outlined in NFPA 90A. A pressure relief damper shall be provided upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed. Acceptance testing of fire dampers shall be performed per paragraph Fire Damper Acceptance Test and NFPA 90A.

#### 2.8.3.3 Splitters and Manual Balancing Dampers

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 3/16 inch rod brought through the side of the duct with locking setscrew and bushing.

Two rods are required on splitters over 8 inches. Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 12 inches. Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

#### 2.8.3.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When

installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in 90 degree elbows.

#### 2.8.4 Duct Sleeves, Framed Prepared Openings, Closure Collars

##### 2.8.4.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 15 inches in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 15 inches in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 20 gauge galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A 53/A 53M, Schedule 20 shall be used. Sleeve shall provide 1 inch clearance between the duct and the sleeve or 1 inch clearance between the insulation and the sleeve for insulated ducts.

##### 2.8.4.2 Framed Prepared Openings

Openings shall have 1 inch clearance between the duct and the opening or 1 inch clearance between the insulation and the opening for insulated ducts.

##### 2.8.4.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 4 inches wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 15 inches in diameter or less shall be fabricated from 20 gauge galvanized steel. Collars for round ducts larger than 15 inches and square, and rectangular ducts shall be fabricated from 18 gauge galvanized steel. Collars shall be installed with fasteners on maximum 6 inch centers, except that not less than 4 fasteners shall be used.

## 2.8.5 Plenums and Casings for Field-Fabricated Units

### 2.8.5.1 Plenum and Casings

Plenums and casings shall be fabricated and erected as shown in SMACNA HVAC Duct Const Stds, as applicable. Unless otherwise indicated, system casing shall be constructed of not less than 16 gauge galvanized sheet steel. Cooling coil drain pans with 1 inch threaded outlet shall be provided to collect condensation from the cooling coils. Drain pans shall be fabricated of not lighter than 16 gauge steel, galvanized after fabrication or of 18 gauge corrosion-resisting sheet steel conforming to ASTM A 167, Type 304, welded and stiffened. Drain pans exposed to the atmosphere shall be thermally insulated to prevent condensation. Insulation shall be coated with a flame resistant waterproofing material. Separate drain pans shall be provided for each vertical coil section, and a separate drain line shall be provided for each pan. Pans shall be generously sized to ensure capture of entrained moisture on the downstream-air side of the coil. Openings in the casing, such as for piping connections, shall be sealed and covered to prevent air leakage. Water seal for the drain shall provide at least 2 inch water gauge greater than the maximum negative pressure in the coil space.

### 2.8.5.2 Casing

Casings shall be terminated at the curb line and anchored by the use of galvanized angle iron sealed and bolted to the curb, as indicated in SMACNA HVAC Duct Const Stds.

### 2.8.5.3 Access Doors

Access doors shall be provided in each section of the casing. Door frames shall be welded in place, and each door shall be neoprene gasketed, hinged with minimum of two brass hinges, and fastened with a minimum of two brass tension fasteners operable from inside and outside of the casing. Where possible, doors shall be 36 x 18 inches located 18 inches above the floor. Where the space available will not accommodate doors of this size, doors as large as the space will accommodate shall be provided. Doors shall swing so that fan suction or pressure holds door in closed position, and shall be airtight. A push-button station to stop the supply fan shall be located inside the casing where indicated.

### 2.8.5.4 Factory-Fabricated Insulated Sheet Metal Panels

Factory-fabricated components may be used for field-assembled units, provided all requirements specified for field-fabricated plenums and casings are met. Panels shall be of modular design, pretested for structural strength, thermal control, condensation control, and acoustical control. Panel joints shall be sealed and insulated access doors shall be provided and gasketed to prevent air leakage. Panel construction shall be not less than 20 gauge galvanized sheet steel and shall be assembled with fasteners treated against corrosion. Standard length panels shall deflect not more than 1/2 inch under operation. Details of construction, including joint sealing, not specifically covered shall be as indicated in SMACNA HVAC Duct Const Stds. The plenums and casings shall be constructed to withstand the specified internal pressure of the air systems.

### 2.8.5.5 Duct Liner

Unless otherwise specified, duct liner shall conform to ASTM C 1071, Type I

or II.

#### 2.8.6 Sound Attenuation Equipment

##### a. Systems With Total Pressure Above 4 Inches Water Gauge:

Sound attenuators shall be provided on the discharge duct of each fan operating at a total pressure above 4 inch water gauge, and, when indicated, at the intake of each fan system. Sound attenuators shall be provided elsewhere as indicated. The sound attenuators shall be factory fabricated and shall be tested by an independent laboratory for sound and performance characteristics. Net sound reduction shall be as indicated. Maximum permissible pressure drop shall not exceed 0.63 inch water gauge. Traps shall be constructed to be airtight when operating under an internal static pressure of 10 inch water gauge. Air-side surface shall be capable of withstanding air velocity of 10,000 fpm. The Contractor shall certify that the sound reduction values specified will be obtained after the equipment is installed in the system and coordinated with the sound information of the system fan to be provided. Sound absorbing material shall conform to ASTM C 1071, Type I or II. Sound absorbing material shall meet the fire hazard rating requirements for insulation specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. A duct transition section shall be provided for connection to ductwork. Factory fabricated double-walled internally insulated spiral lock seam and round duct and fittings designed for high pressure air system may be provided in lieu of factory fabricated sound attenuators, and shall comply with requirements specified for factory fabricated sound attenuators. The double-walled duct and fittings shall be constructed of an outer metal pressure shell of zinc-coated steel sheet, 1 inch thick acoustical blanket insulation, and an internal perforated zinc-coated metal liner. Sufficient length of run shall be provided to obtain the noise reduction coefficient specified. The Contractor shall certify that the sound reduction value specified will be obtained within the length of duct run provided. The outer sheet metal of the double-walled duct shall have welded, or spiral lock, seams to prevent water vapor penetration. The outer sheet of the duct and fittings shall conform to the metal thickness of high pressure spiral and round ducts and fittings shown in SMACNA HVAC Duct Const Stds. The acoustical insulation shall have a thermal conductivity "k" of not more than 0.27 Btu/inch/square foot/hour/degree F at 75 degrees F mean temperature. The internal perforated zinc-coated metal liner shall be not less than 24 gauge with perforations not larger than 1/4 inch in diameter providing a net open area not less than 10 percent of the surface.

##### b. System With Total Pressure of 4 Inch Water Gauge and Lower:

Sound attenuators shall be provided only where indicated, or in lieu of lined ducts. Factory fabricated sound attenuators shall be constructed of galvanized steel sheets. Outer casing shall be not less than 22 gauge. Acoustical fill shall be fibrous glass. Net sound reduction shall be as indicated. Values shall be obtained on a test unit not less than 24 by 24 inches outside dimensions made by a certified nationally recognized independent acoustical laboratory. Air flow capacity shall be as indicated or required. Pressure drop through the attenuator shall not exceed the value indicated, or shall not be in excess of 15 percent of the total external static pressure of the air handling system, whichever is less. Sound attenuators shall be acoustically tested with metal duct inlet and outlet sections while under the rated air flow conditions. Noise reduction data shall include the effects of flanking paths and vibration transmission. Sound attenuators shall be constructed to be airtight when

operating at the internal static pressure indicated or specified for the duct system, but in no case less than 2 inch water gauge.

c. Acoustical Duct Liner:

Acoustical duct lining shall be fibrous glass designed exclusively for lining ductwork and shall conform to the requirements of ASTM C 1071, Type I and II. Liner composition may be uniform density, graduated density, or dual density, as standard with the manufacturer. Lining shall be coated, not less than 1 inch thick. Where acoustical duct liner is used, liner or combination of liner and insulation applied to the exterior of the ductwork shall be the thermal equivalent of the insulation specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Duct sizes shown shall be increased to compensate for the thickness of the lining used. In lieu of sheet metal duct with field-applied acoustical lining, acoustically equivalent lengths of fibrous glass duct or factory fabricated double-walled internally insulated duct with perforated liner may be provided. Net insertion loss value, static pressure drop, and air flow velocity capacity data shall be certified by a nationally recognized independent acoustical laboratory.

2.8.7 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of steel, corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers, except linear slot diffusers. Linear slot diffusers shall be provided with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, they shall be protected by a grille or screen according to NFPA 90A.

2.8.7.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Air handling troffers or combination light and ceiling diffusers shall conform to the requirements of UL Elec Const Dir for the interchangeable use as cooled or heated air supply diffusers or return air units. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.8.7.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and

exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 6 inches below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 6 inches above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

#### 2.8.8 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07600A SHEET METALWORK, GENERAL.

#### 2.8.9 Air Vents, Penthouses, and Goosenecks

Air vents, penthouses, and goosenecks shall be fabricated from galvanized steel or aluminum sheets with galvanized [or aluminum] structural shapes. Sheet metal thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Louver blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Air vents, penthouses, and goosenecks shall be provided with bird screen.

#### 2.8.10 Bird Screens and Frames

Bird screens shall conform to ASTM E 437, No. 2 mesh, aluminum or stainless steel. Aluminum screens shall be rated "medium-light". Stainless steel screens shall be rated "light". Frames shall be removable type, or stainless steel or extruded aluminum.

#### 2.8.11 Radon Exhaust Ductwork

Radon exhaust ductwork installed in or beneath slabs shall be fabricated from Schedule 40 PVC pipe that conforms to ASTM D 1785. Fittings shall conform to ASTM D 2466. Solvent cement used to make joints shall conform to ASTM D 2564. Otherwise radon exhaust ductwork shall be metal as specified herein.

### 2.9 AIR SYSTEMS EQUIPMENT

#### 2.9.1 Fans

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 15 hp and below and fixed pitch as defined by ARI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless



otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings as indicated. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

#### 2.9.1.1 Centrifugal Fans

Centrifugal fans shall be fully enclosed, single-width single-inlet, or double-width double-inlet, AMCA Pressure Class I, II, or III as required or indicated for the design system pressure. Impeller wheels shall be rigidly constructed, accurately balanced both statically and dynamically. Fan wheels over 36 inches in diameter shall have overhung pulleys and a bearing on each side of the wheel. Fan wheels 36 inches or less in diameter may have one or more extra long bearings between the fan wheel and the drive. Bearings shall be sleeve type, self-aligning and self-oiling with oil reservoirs, or precision self-aligning roller or ball-type with accessible grease fittings or permanently lubricated type. Grease fittings shall be connected to tubing and serviceable from a single accessible point. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Fan shafts shall be steel, accurately finished, and shall be provided with key seats and keys for impeller hubs and fan pulleys. Each fan outlet shall be of ample proportions and shall be designed for the attachment of angles and bolts for attaching flexible connections. Motors, unless otherwise indicated, shall not exceed 1800 rpm.

#### 2.9.1.2 In-Line Centrifugal Fans

In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Fans shall be mounted in a welded tubular casing. Air shall enter and leave the fan axially. Inlets shall be streamlined with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision self aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11.

#### 2.9.1.3 Axial Flow Fans

Axial flow fans shall be complete with drive components and belt guard, and shall have a steel housing, cast fan wheel, cast or welded steel diffusers, fan shaft, bearings, and mounting frame as a factory-assembled unit. Fan wheels shall have radially projecting blades of airfoil cross section and shall be dynamically balanced and keyed to the fan shaft. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt, shall be permanently lubricated or with accessible grease fittings, and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours of operation as defined by ABMA 9 and ABMA 11. Fan inlets shall be provided with an aerodynamically shaped bell and an inlet cone. Diffuser or straightening vanes shall be provided at the fan discharge to minimize turbulence and provide smooth discharge air flow.

#### 2.9.1.4 Panel Type Power Wall Ventilators

Fans shall be propeller type, assembled on a reinforced metal panel with venturi opening spun into panel. Fans with wheels less than 24 inches in diameter shall be direct or V-belt driven and fans with wheels 24 inches diameter and larger shall be V-belt drive type. Fans shall be furnished with wall mounting collar. Lubricated bearings shall be provided. Fans shall be fitted with wheel and motor side metal or wire guards which have a corrosion-resistant finish.

#### 2.9.1.5 Centrifugal Type Power Wall Ventilators

Fans shall be direct or V-belt driven centrifugal type with backward inclined, non-overloading wheel. Motor housing shall be removable and weatherproof. Unit housing shall be designed for sealing to building surface and for discharge and condensate drippage away from building surface. Housing shall be constructed of heavy gauge aluminum. Unit shall be fitted with an aluminum or plated steel wire discharge bird screen, wall grille, manufacturer's standard damper, an airtight and liquid-tight metallic wall sleeve.

#### 2.9.1.6 Centrifugal Type Power Roof Ventilators

Fans shall be direct or V-belt driven with backward inclined, non-overloading wheel. Motor compartment housing shall be hinged or removable and weatherproof, constructed of heavy gauge aluminum. Fans shall be provided with birdscreen, disconnect switch, dampers, roof curb, and extended base. Lubricated bearings shall be provided.

#### 2.9.1.7 Ceiling Exhaust Fans

Suspended cabinet-type ceiling exhaust fans shall be centrifugal type, direct-driven. Fans shall have acoustically insulated housing. Integral backdraft damper shall be chatter-proof. The integral face grille shall be of egg-crate design or louver design. Fan motors shall be mounted on vibration isolators. Unit shall be provided with mounting flange for hanging unit from above. Fans shall be U.L. listed.

#### 2.9.2 Coils

Coils shall be fin-and-tube type constructed of seamless copper or red brass tubes and aluminum or copper fins mechanically bonded or soldered to the tubes. Casing and tube support sheets shall be not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at not less than 400 psi air pressure and shall be suitable for 200 psi working pressure. Coils shall be mounted for counterflow service. Coils shall be rated and certified according to ARI 410.

#### 2.9.3 Air Filters

Air filters shall be listed according to requirements of UL 900, except high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method shall be as listed under the Label Service and shall meet the requirements of UL 586.

#### 2.9.3.1 Holding Frames

Frames shall be fabricated from not lighter than 16 gauge sheet steel with rust-inhibitor coating. Each holding frame shall be equipped with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

#### 2.9.3.2 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure taps with integral compression fittings, two molded plastic vent valves, two 5 foot minimum lengths of 1/4 inch diameter tubing, and all hardware and accessories for gauge mounting.

### 2.10 AIR HANDLING UNITS

#### 2.10.1 Field-Fabricated Air Handling Units

Built-up units shall be as specified in paragraph DUCTWORK COMPONENTS. Fans, coils spray-coil dehumidifiers, and air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types indicated.

#### 2.10.2 Factory-Fabricated Air Handling Units

Air handling unit shall have published ratings based on tests performed according to ARI 430.

##### 2.10.2.1 Casings

Casing sections shall be constructed of a minimum 18 gauge galvanized steel, or 18 gauge steel outer casing protected with a corrosion resistant paint finish according to paragraph FACTORY PAINTING. Casing shall be designed and constructed with an integral insulated structural steel frame such that exterior panels are non-load bearing. Exterior panels shall be individually removable. Removal shall not affect the structural integrity of the unit. Casings shall be provided with inspection doors, access sections, and access doors as indicated. Inspection and access doors shall be insulated, fully gasketed, double-wall type, of a minimum 18 gauge outer and 20 gauge inner panels. Doors shall be rigid and provided with heavy duty hinges and latches. Inspection doors shall be a minimum 12 inches wide by 12 inches high. Access doors shall be minimum 24 inches wide and shall be the full height of the unit casing or a minimum of 6 foot, whichever is less. Drain pan shall be double-wall insulated type constructed of 16 gauge stainless steel, pitched to the drain connection. Drain pans shall be constructed water tight, treated to prevent corrosion, and designed for positive condensate drainage. When 2 or more cooling coils are used, with one stacked above the other, condensate from the upper coils shall not flow across the face of lower coils. Intermediate drain pans or condensate collection channels and downspouts shall be provided, as required to carry condensate to the unit drain pan out of the air stream and without moisture carryover. Drain pan shall be constructed so that the pan may be visually inspected easily including underneath the coil without removal of the coil and so that the pan may be physically cleaned completely and easily underneath the coil without removal of the coil. Casing insulation shall conform to NFPA 90A. Single-wall casing sections handling conditioned air shall be insulated with not less than 1 inch

thick, 1-1/2 pound density coated fibrous glass material having a thermal conductivity not greater than 0.23 Btu/hr-sf-F. Double-wall casing sections handling conditioned air shall be insulated with not less than 2 inches of the same insulation specified for single-wall casings. Foil-faced insulation shall not be an acceptable substitute for use with double wall casing. Double wall insulation must be completely sealed by inner and outer panels. Factory applied fibrous glass insulation shall conform to ASTM C 1071, except that the minimum thickness and density requirements do not apply, and shall meet the requirements of NFPA 90A. Air handling unit casing insulation shall be uniform over the entire casing. Foil-faced insulation shall not be an acceptable substitute for use on double-wall access doors and inspections doors. Duct liner material, coating, and adhesive shall conform to fire-hazard requirements specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Exposed insulation edges and joints where insulation panels are butted together shall be protected with a metal nosing strip or shall be coated to conform to meet erosion resistance requirements of ASTM C 1071. A latched and hinged inspection door, shall be provided in the fan and coil sections.

#### 2.10.2.2 Heating and Cooling Coils

Coils shall be provided as specified in paragraph AIR SYSTEMS EQUIPMENT, for types indicated.

#### 2.10.2.3 Cooling Coils, Spray Type

Cooling coils shall be of the copper finned type as specified in paragraph AIR SYSTEMS EQUIPMENT furnished complete with water sprays. All horizontal units and vertical units with coil face velocities of 550 fpm or above, shall be provided with moisture eliminators. Sprays shall have all bronze, brass, or stainless steel centrifugal type nozzles, with removable caps designed and arranged for uniform wetting of the entire coil face area. Nozzles shall be supplied by standard weight galvanized steel piping and a centrifugal type circulating pump furnished as an integral part of the unit. Eliminators shall be not lighter than 24 gauge corrosion-resistant steel, removable for maintenance and coil inspection. No water shall carry over into the fan section or supply ducts from the air handling unit provided with or without eliminators.

#### 2.10.2.4 Air Filters

Air filters shall be as specified in paragraph AIR SYSTEMS EQUIPMENT for types and thickness indicated.

#### 2.10.2.5 Fans

Fans shall be double-inlet, centrifugal type with each fan in a separate scroll. Fans and shafts shall be dynamically balanced prior to installation into air handling unit, then the entire fan assembly shall be statically and dynamically balanced at the factory after it has been installed in the air handling unit. Fans shall be mounted on steel shafts accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by ABMA 9 and ABMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings readily accessible at the drive side of the unit.

Bearings shall be supported by structural shapes, or die formed sheet structural members, or support plates securely attached to the unit casing. Bearings may not be fastened directly to the unit sheet metal casing.

Fans and scrolls shall be furnished with coating indicated. Fans shall be driven by a unit-mounted or a floor-mounted motor connected to fans by V-belt drive complete with belt guard for externally mounted motors. Belt guards shall be the three sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than a 1.3 service factor based on motor nameplate rating. Where fixed sheaves are required, variable pitch sheaves may be used during air balance, but shall be replaced with an appropriate fixed sheave after air balance is completed. Variable pitch sheaves shall be selected to drive the fan at a speed that will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. Motors for V-belt drives shall be provided with adjustable bases. Unit fan or fans shall be selected to produce the required capacity at the fan static pressure. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300, ASHRAE 68, or ARI 260.

#### 2.10.2.6 Access Sections and Filter/Mixing Boxes

Access sections shall be provided where indicated and shall be furnished with access doors as shown. Access sections and filter/mixing boxes shall be constructed in a manner identical to the remainder of the unit casing and shall be equipped with access doors. Mixing boxes shall be designed to minimize air stratification and to promote thorough mixing of the air streams.

#### 2.10.2.7 Diffuser Sections

Diffuser sections shall be furnished between the discharge of all housed supply fans and cooling coils of blow-through single zone units and filter sections of those units with high efficiency filters located immediately downstream of the air handling unit fan section. Diffuser sections shall be fabricated by the unit manufacturer in a manner identical to the remainder of the unit casing, shall be designed to be airtight under positive static pressures up to 8 inches water gauge and shall have an access door on each side for inspection purposes. Diffuser section shall contain a perforated diffusion plate, fabricated of galvanized steel, Type 316 stainless steel, aluminum, or steel treated for corrosion with manufacturer's standard corrosion-resisting finish.

#### 2.10.2.8 Dampers

Dampers shall be as specified in paragraph CONTROLS.

### 2.11 TERMINAL UNITS

#### 2.11.1 Variable Air Volume (VAV) and Dual Duct Terminal Units

VAV and dual duct terminal units shall be the type, size, and capacity shown and shall be mounted in the ceiling or wall cavity and shall be suitable for single or dual duct system applications. Actuators and controls shall be as specified in paragraph CONTROLS. Unit enclosures shall be constructed of galvanized steel not lighter than 22 gauge or aluminum sheet not lighter than 18 gauge. Single or multiple discharge outlets shall be provided as required. Units with flow limiters are not acceptable. Unit air volume shall be factory preset and readily field adjustable without special tools. Reheat coils shall be provided as indicated. A flow chart shall be attached to each unit. Acoustic performance of the terminal units shall be based upon units tested according to ARI 880. Sound power level shall be as indicated. Acoustical

lining shall be according to NFPA 90A.

#### 2.11.1.1 Constant Volume, Single Duct

Constant volume, single duct, terminal units shall contain within the casing, a mechanical or pneumatic constant volume regulator. Volume regulators shall control air delivery to within plus or minus 5 percent of specified air flow subjected to inlet pressure from 3/4 to 6 inch water gauge.

#### 2.11.1.2 Variable Volume, Single Duct

Variable volume, single duct, terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, and accessory relays. Units shall control air volume to within plus or minus 5 percent of each air set point volume as determined by the thermostat with variations in inlet pressures from 3/4 to 6 inch water gauge. Internal resistance of units shall not exceed 0.4 inch water gauge at maximum flow range. External differential pressure taps separate from the control pressure taps shall be provided for air flow measurement with a 0 to 1 inch water gauge range. Unit volume controller shall be normally [open] [closed] upon loss of pneumatic pressure.

#### 2.11.1.3 Variable Volume, Single Duct, Fan-Powered

Variable volume, single duct, fan-powered terminal units shall be provided with a calibrated air volume sensing device, air valve or damper, actuator, fan and motor, and accessory relays. Units shall control primary air volume to within plus or minus 5 percent of each air set point as determined by the thermostat with variations in inlet pressure from 3/4 to 6 inch water gauge. Unit fan shall be centrifugal, direct-driven, double-inlet type with forward curved blades. Fan motor shall be either single speed with speed controller or three-speed, permanently lubricated, permanent split-capacitor type. Fan/motor assembly shall be isolated from the casing to minimize vibration transmission. Fan control shall be factory furnished and wired into the unit control system. A factory-mounted pressure switch shall be furnished to operate the unit fan whenever pressure exists at the unit primary air inlet or when the control system fan operates.

#### 2.11.1.4 Reheat Units

a. Hot Water Coils: Hot-water coils shall be fin-and-tube type constructed of seamless copper tubes and copper or aluminum fins mechanically bonded or soldered to the tubes. Headers shall be constructed of cast iron, welded steel or copper. Casing and tube support sheets shall be 16 gauge, galvanized steel, formed to provide structural strength. Tubes shall be correctly circuited for proper water velocity without excessive pressure drop and they shall be drainable where required or indicated. At the factory, each coil shall be tested at not less than 250 psi air pressure and shall be suitable for 200 psi working pressure. Drainable coils shall be installed in the air handling units with a pitch of not less than 1/8 inch per foot of tube length toward the drain end. Coils shall conform to the provisions of ARI 410.

## 2.12 ENERGY RECOVERY DEVICES

### 2.12.1 Rotary Wheel

Unit shall be a factory fabricated and tested assembly for air-to-air energy recovery by transfer of sensible heat from exhaust air to supply air stream. Device performance shall be according to ASHRAE 84. Exchange media shall be chemically inert, moisture-resistant, fire-retardant, laminated, nonmetallic material which complies with NFPA 90A. Exhaust and supply streams shall be isolated by seals which are static, field adjustable, and replaceable. Chain drive mechanisms shall be fitted with ratcheting torque limiter or slip-clutch protective device. Enclosure shall be fabricated from galvanized steel and shall include maintenance access provisions. Recovery control and rotation failure provisions shall be as indicated.

## 2.13 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 1/8 inch. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

#### 3.1.1 Piping

Pipe and fitting installation shall conform to the requirements of ASME B31.1. Pipe shall be cut accurately to measurements established at the jobsite, and worked into place without springing or forcing, completely clearing all windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipe or tubing shall be cut square, shall have burrs removed by reaming, and shall permit free expansion and contraction without causing damage to the building structure, pipe, joints, or hangers. Changes in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Horizontal supply mains shall pitch down in the direction of flow as indicated. The grade shall be not less than 1 inch in 40 feet. Reducing fittings shall be used for changes in pipe sizes. Open ends of pipelines and equipment shall be capped or plugged during installation to keep dirt or other foreign materials out of

the system. Pipe not otherwise specified shall be uncoated. Connections to appliances shall be made with malleable iron unions for steel pipe 2-1/2 inches or less in diameter, and with flanges for pipe 3 inches and larger. Connections between ferrous and copper piping shall be electrically isolated from each other with dielectric unions or flanges. All piping located in air plenums shall conform to NFPA 90A requirements. Pipe and fittings installed in inaccessible conduits or trenches under concrete floor slabs shall be welded.

#### 3.1.1.1 Joints

a. Threaded Joints: Threaded joints shall be made with tapered threads and made tight with a stiff mixture of graphite and oil or polytetrafluoroethylene tape or equivalent thread joint compound or material, applied to the male threads only.

b. Soldered Joints: Joints in copper tubing shall be cut square with ends reamed, and all filings and dust wiped from interior of pipe. Joints shall be soldered with 95/5 solder or brazed with silver solder applied and drawn through the full fitting length. Care shall be taken to prevent annealing of tube or fittings when making connections. Joints 2-1/2 inches and larger shall be made with heat uniformly around the entire circumference of the joint with a multi-flame torch. Connections in floor slabs shall be brazed. Excess solder shall be wiped from joint before solder hardens. Solder flux shall be liquid or paste form, non-corrosive and conform to ASTM B 813.

c. Welded Joints : Welded joints shall be fusion welded unless otherwise required. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or branch outlet fittings. Branch outlet fittings shall be forged, flared for improvement of flow where attached to the run, and reinforced against external strains. Beveling, alignment, heat treatment and inspection of weld shall conform to ASME B31.1. Weld defects shall be removed and repairs made to the weld, or the weld joints shall be entirely removed and rewelded. Electrodes shall be stored and dried according to AWS D1.1/D1.1M or as recommended by the manufacturer. Electrodes that have been wetted or that have lost any of their coating shall not be used.

#### 3.1.1.2 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Groove width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations, such as behind solid walls or ceilings, unless an access panel is shown on the drawings for servicing or adjusting the joint.



### 3.1.1.3 Flanges and Unions

Except where copper tubing is used, union or flanged joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items.

### 3.1.2 Supports

#### 3.1.2.1 General

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. Supports shall not be attached to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

#### 3.1.2.2 Seismic Requirements (Pipe Supports and Structural Bracing)

Piping and attached valves shall be supported and braced to resist seismic loads as specified under Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070A SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided under this section.

#### 3.1.2.3 Pipe Hangers, Inserts and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Types 5, 12, and 26 shall not be used.

- a. Hangers: Type 3 shall not be used on insulated piping.
- b. Inserts: Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.
- c. C-Clamps: Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.
- d. Angle Attachments: Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.
- e. Hangers: Type 24 may be used only on trapeze hanger systems or on fabricated frames.
- f. Type 39 saddles shall be used on all insulated pipe 4 inches and larger when the temperature of the medium is above 60 degrees F. Type 39 saddles shall be welded to the pipe.
- g. Type 40 shields shall:

(1) be used on all insulated pipes less than 4 inches.

(2) be used on all insulated pipes 4 inches and larger when the temperature of the medium is 60 degrees F or less.

(3) have a high density insert for pipe 2 inches and larger, and for smaller pipe when the insulation shows signs of being visibly compressed, or when the insulation or jacket shows visible signs of distortion at or near the type 40 shield. High density inserts shall have a density of 9 pcf or greater.

h. Horizontal Pipe Supports: Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves.

i. Vertical Pipe Supports: Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.

j. Pipe Guides: Type 35 guides using steel reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

k. Steel Slides: Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger with medium 60 degrees F or greater, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

l. High Temperature Guides with Cradles: Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches, or by an amount adequate for the insulation, whichever is greater.

m. Insulated Pipe: Insulation on horizontal pipe shall be continuous through hangers for hot and cold piping. Other requirements on insulated pipe are specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

### 3.1.3 Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation

or by the weight of expansion of the pipeline.

#### 3.1.4 Pipe Sleeves

Sleeves shall not be installed in structural members except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Unless otherwise indicated, sleeves shall provide a minimum of 1/4 inch all-around clearance between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be steel pipe or cast iron pipe. Sleeves in non-bearing walls, floors, or ceilings may be steel pipe, cast iron pipe, galvanized sheet metal with lock-type longitudinal seam and of the metal thickness indicated, or moisture resistant fiber or plastic. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve, in non-fire rated walls, shall be sealed as indicated and specified in Section 07900A JOINT SEALING. Pipes passing through wall waterproofing membrane shall be sleeved as specified above, and a waterproofing clamping flange shall be installed as indicated.

##### 3.1.4.1 Roof and Floor Sleeves

Pipes passing through roof or floor waterproofing membrane shall be installed through a 17-ounce copper sleeve or a 0.032 inch thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 8 inches from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. Unless otherwise shown, the flashing sleeve shall extend up the pipe a minimum of 2 inches above highest floor level or a minimum of 10 inches above the roof. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess. In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

##### 3.1.4.2 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, a fire seal shall be provided as specified in Section 07840A FIRESTOPPING.

#### 3.1.4.3 Escutcheons

Escutcheons shall be provided at finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheons shall be secured to pipe or pipe covering.

#### 3.1.5 Condensate Drain Lines

Water seals shall be provided in the condensate drain from all [units.] [units except room [fan-coil units] [and] [coil-induction units]]. The depth of each seal shall be 2 inches plus the number of inches, measured in water gauge, of the total static pressure rating of the unit to which the drain is connected. Water seals shall be constructed of 2 tees and an appropriate U-bend with the open end of each tee plugged. Pipe cap or plug cleanouts shall be provided where indicated. Drains indicated to connect to the sanitary waste system shall be connected by an indirect waste fitting. Air conditioner drain lines shall be insulated as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

#### 3.1.6 Pipe-Alignment Guides

Pipe-alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 5 feet on each side of each expansion joint, and in lines 4 inches or smaller not more than 2 feet on each side of the joint.

#### 3.1.7 Air Vents and Drains

##### 3.1.7.1 Vents

Air vents shall be provided at high points, on water coils, and where indicated to ensure adequate venting of the piping system.

##### 3.1.7.2 Drains

Drains shall be provided at low points and where indicated to ensure complete drainage of the piping. Drains shall be accessible, and shall consist of nipples and caps or plugged tees unless otherwise indicated.

#### 3.1.8 Valves

Isolation gate or ball valves shall be installed on each side of each piece of equipment such as pumps, heaters, heating or cooling coils, and other similar items, at the midpoint of all looped mains, and at any other points indicated or required for draining, isolating, or sectionalizing purposes. Isolation valves may be omitted where balancing cocks are installed to provide both balancing and isolation functions. Each valve except check valves shall be identified. Valves in horizontal lines shall be installed with stems horizontal or above.

#### 3.1.9 Equipment and Installation

Frames and supports shall be provided for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Air handling units shall be floor mounted or ceiling hung, as indicated. The method of anchoring and fastening shall be as

detailed. Floor-mounted equipment, unless otherwise indicated, shall be set on not less than 6 inch concrete pads or curbs doweled in place. Concrete foundations for circulating pumps shall be heavy enough to minimize the intensity of the vibrations transmitted to the piping and the surrounding structure, as recommended in writing by the pump manufacturer. In lieu of a concrete pad foundation, a concrete pedestal block with isolators placed between the pedestal block and the floor may be provided. The concrete foundation or concrete pedestal block shall be of a mass not less than three times the weight of the components to be supported. Lines connected to the pump mounted on pedestal blocks shall be provided with flexible connectors. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

#### 3.1.10 Access Panels

Access panels shall be provided for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500A MISCELLANEOUS METALS.

#### 3.1.11 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

#### 3.1.12 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840A FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07900A JOINT SEALING.

#### 3.1.13 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

##### 3.1.13.1 Underground Ductwork

Underground ductwork shall be PVC plastisol coated galvanized steel with coating on interior and exterior surfaces and watertight joints. Ductwork

shall be installed as indicated, according to ACCA Manual 4 and manufacturer's instructions. Maximum burial depth shall be 6 feet.

#### 3.1.13.2 Radon Exhaust Ductwork

Subslab suction piping shall be perforated where indicated. PVC joints shall be installed as specified in ASTM D 2855.

#### 3.1.13.3 Light Duty Corrosive Exhaust Ductwork

Light duty corrosive exhaust ductwork shall be PVC plastisol coated galvanized steel with PVC coating on interior [surfaces.] [and exterior surfaces] [and epoxy wash primer coating on exterior surfaces].

#### 3.1.14 Fibrous Glass Ductwork

Installation shall be according to the manufacturer's written recommendations unless otherwise required in NAIMA AH115. Duct supports for fibrous glass ductwork shall conform to NAIMA AH115. In those cases not covered in NAIMA AH115, the written recommendation of the fibrous duct manufacturer shall be followed.

#### 3.1.15 FRP Ductwork

Fibrous glass reinforced plastic ducting and related structures shall conform to SMACNA Industry Practice. Flanged joints shall be provided where indicated. Crevice-free butt lay-up joints are acceptable where flanged joints are not indicated. When ambient temperatures are lower than 50 degrees F, joints shall be heat cured by exothermic reaction heat packs.

#### 3.1.16 Acoustical Duct Lining

Lining shall be applied in cut-to-size pieces attached to the interior of the duct with nonflammable fire resistant adhesive conforming to ASTM C 916, Type I, NFPA 90A, UL 723, and ASTM E 84. Top and bottom pieces shall lap the side pieces and shall be secured with welded pins, adhered clips of metal, nylon, or high impact plastic, and speed washers or welding cup-head pins installed according to SMACNA HVAC Duct Const Stds. Welded pins, cup-head pins, or adhered clips shall not distort the duct, burn through, nor mar the finish or the surface of the duct. Pins and washers shall be flush with the surfaces of the duct liner and all breaks and punctures of the duct liner coating shall be sealed with the nonflammable, fire resistant adhesive. Exposed edges of the liner at the duct ends and at other joints where the lining will be subject to erosion shall be coated with a heavy brush coat of the nonflammable, fire resistant adhesive, to prevent delamination of glass fibers. Duct liner may be applied to flat sheet metal prior to forming duct through the sheet metal brake. Lining at the top and bottom surfaces of the duct shall be additionally secured by welded pins or adhered clips as specified for cut-to-size pieces. Other methods indicated in SMACNA HVAC Duct Const Stds to obtain proper installation of duct liners in sheet metal ducts, including adhesives and fasteners, will be acceptable.

#### 3.1.17 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work.

Temporary protection shall remain in place until system is ready for startup.

#### 3.1.18 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS. Outdoor air intake ducts and plenums shall be externally insulated up to the point where the outdoor air reaches the conditioning unit or up to the point where the outdoor air mixes with the outside air stream.

#### 3.1.19 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

#### 3.1.20 Power Roof Ventilator Mounting

Foamed 1/2 inch thick, closed-cell, flexible elastomer insulation shall cover width of roof curb mounting flange. Where wood nailers are used, holes shall be pre-drilled for fasteners.

#### 3.1.21 Power Transmission Components Adjustment

V-belts and sheaves shall be tested for proper alignment and tension prior to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct driven couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

### 3.2 FIELD PAINTING AND IDENTIFICATION SYSTEMS

#### 3.2.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number shall be installed on all valves and dampers. Tags shall be 1-3/8 inch minimum diameter and marking shall be stamped or engraved. Indentations shall be black for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain or plastic straps designed for that purpose.

#### 3.2.2 Finish Painting and Pipe Color Code Marking

Finish painting of items only primed at the factory, surfaces not specifically noted otherwise, and color code marking for piping shall be as specified in Section 09900 PAINTS AND COATINGS.

#### 3.2.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 3/8 inch diameter and secured to removable ceiling panels with fasteners. Each fastener shall be inserted

into the ceiling panel so as to be concealed from view. The fasteners shall be manually removable without the use of tools and shall not separate from the ceiling panels when the panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall be approximately 3 foot wide, 30 inches high, and 1/2 inches thick. The board shall be made of wood fiberboard and framed under glass or 1/16 inch transparent plastic cover. The color code symbols shall be approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters.

### 3.3 PIPING HYDROSTATIC TEST

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure will be allowed. Leaks shall be repaired by re-welding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before covering or concealing.

### 3.4 DUCTWORK LEAK TEST

Ductwork leak test shall be performed for the entire air distribution and exhaust system, including fans, coils, filters, etc. Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

### 3.5 DAMPER ACCEPTANCE TEST

All fire dampers and smoke dampers shall be operated under normal operating conditions, prior to the occupancy of a building to determine that they function properly. Fire dampers equipped with fusible links shall be tested by having the fusible link cut in place. Dynamic fire dampers shall be tested with the air handling and distribution system running. All fire dampers shall be reset with the fusible links replaced after acceptance testing. To ensure optimum operation and performance, the damper must be installed so it is square and free from racking.

### 3.6 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 15990A TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

### 3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the



humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

### 3.8 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of foreign matter. A temporary bypass shall be provided for water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Inside of fan-coil units, air terminal units, ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

### 3.9 FIELD TRAINING

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 8 hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --